



PEACE/WILLISTON  
FISH & WILDLIFE  
COMPENSATION  
PROGRAM

**BChydro** 



## **Inventory of Fishers in the Sub-boreal Forests of North-central British Columbia Year III (1998/99): Radiotelemetry Monitoring**

---

R. D. Weir  
May 1999

PWFWCP Report No. 206

The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

**Peace/Williston Fish and Wildlife Compensation Program, 1011 Fourth Ave.  
3<sup>rd</sup> Floor, Prince George B.C. V2L 3H9**

Website: [www.bchydro.bc.ca/environment/initiatives/pwcp/](http://www.bchydro.bc.ca/environment/initiatives/pwcp/)

**This report has been approved by the Peace/Williston Fish and Wildlife  
Compensation Program Fish Technical Committee.**

**Citation:** R. D. Weir. May 1999. Inventory of fishers in the sub-boreal forests of north-central British Columbia Year III (1998/99): radiotelemetry monitoring. Peace/Williston Fish and Wildlife Compensation Program, Report No. 206. 39pp plus appendices.

**Author(s):** Richard D. Weir<sup>1</sup>  
**Address(es):** <sup>1</sup> Artemis Wildlife Consultants, C-15 Pringle, Westwold B.C. V0E 3B0

## Abstract

We monitored 11 radio-tagged fishers between 1 April 1998 and 29 January 1999 as part of the third year of a 5-year project examining the ecology of fishers in sub-boreal landscapes of north-central British Columbia. The broad objectives of the radiotelemetry phase of the study were to document the home ranges, movements, and habitat selectivity of fishers.

From data collected during the first 3 years of the study, we estimated annual home ranges for 6 fishers (1 M, 5 F), 1 winter home range, and 6 summer home ranges (1 M, 5 F). We calculated annual and seasonal home ranges from the 90% isopleth of the utilisation distribution using the fixed kernel method. The mean home range size for females was smaller than that of the one male that we monitored for both annual and summer home ranges (annual:  $\bar{x}_{\text{female}} = 43.9 \text{ km}^2$ ,  $\text{SE} = 11.4$ ,  $n = 5$ ; male =  $281.8 \text{ km}^2$ ; summer:  $\bar{x}_{\text{female}} = 47.3 \text{ km}^2$ ,  $\text{SE} = 22.0$ ,  $n = 5$ ; male =  $220.5 \text{ km}^2$ ). The home ranges that we observed were larger than that reported elsewhere, likely because of differences in the distribution of resources between our study area and other regions.

We assigned 440 locations collected during the study to one of six precision categories. We used these precision categories to determine the suitability of each location for habitat analyses at four spatial scales. In total, we collected 32 locations suitable for element-scale analyses, 115 locations for patch-scale analyses, 234 locations for stand-scale analyses, and 440 locations for landscape-scale (home range) analyses. However, because of analysis constraints, the effective sample sizes were 173 locations of 7 fishers for stand-scale analyses and 338 locations of 8 fishers for landscape-scale analyses. We have not yet completed habitat selectivity analyses.

We recorded 6 radio-tagged female fishers using natal and maternal dens during 2 breeding seasons (April-May). We located 8 natal dens of 6 female fishers and documented the use of 4 maternal dens of 3 fishers; however, we were unable to assess productivity of the females. We recorded female fishers denning exclusively in large diameter, declining black cottonwood or balsam poplar trees. The unique decay characteristics of these large diameter trees likely makes them suitable elements for rearing kits.

**TABLE OF CONTENTS**

|                                |           |
|--------------------------------|-----------|
| <b>ABSTRACT</b>                | <b>i</b>  |
| <b>LIST OF TABLES</b>          | <b>iv</b> |
| <b>LIST OF FIGURES</b>         | <b>v</b>  |
| <b>1.0 INTRODUCTION</b>        | <b>1</b>  |
| <b>2.0 STUDY AREA</b>          | <b>2</b>  |
| <b>3.0 METHODS</b>             | <b>5</b>  |
| 3.1 Capturing                  | 5         |
| 3.2 Immobilisation and Tagging | 6         |
| 3.3 Radiotelemetry Monitoring  | 7         |
| 3.4 Home Range and Movements   | 8         |
| 3.5 Habitat Use                | 9         |
| 3.6 Reproduction               | 11        |
| <b>4.0 RESULTS</b>             | <b>11</b> |
| 4.1 Captures                   | 12        |
| 4.2 Immobilisation and Tagging | 12        |
| 4.3 Radiotelemetry Monitoring  | 12        |
| 4.4 Mortalities                | 14        |
| 4.5 Home Range and Movements   | 14        |
| 4.6 Habitat Use                | 19        |
| 4.6.1 Landscape Scale          | 19        |
| 4.6.2 Stand Scale              | 19        |
| 4.6.3 Patch Scale              | 21        |
| 4.6.4 Element Scale            | 21        |

|                                             |           |
|---------------------------------------------|-----------|
| <b>4.7 Reproduction.....</b>                | <b>24</b> |
| <b>5.0 DISCUSSION.....</b>                  | <b>28</b> |
| <b>5.1 Capturing.....</b>                   | <b>28</b> |
| <b>5.2 Immobilisations and Tagging.....</b> | <b>28</b> |
| <b>5.3 Radiotelemetry Monitoring.....</b>   | <b>29</b> |
| <b>5.4 Mortalities.....</b>                 | <b>30</b> |
| <b>5.5 Home Range and Movements.....</b>    | <b>30</b> |
| <b>5.6 Habitat Use.....</b>                 | <b>32</b> |
| 5.6.1 Landscape Scale.....                  | 32        |
| 5.6.2 Stand Scale.....                      | 32        |
| 5.6.3 Patch Scale.....                      | 33        |
| 5.6.4 Element Scale.....                    | 33        |
| 5.6.4.1 Natal and Maternal Dens.....        | 33        |
| 5.6.4.2 Resting Sites.....                  | 34        |
| <b>5.7 Reproduction.....</b>                | <b>34</b> |
| 5.7.1 Den Attentiveness Monitoring.....     | 35        |
| <b>6.0 CONCLUSIONS.....</b>                 | <b>36</b> |
| <b>7.0 LITERATURE CITED.....</b>            | <b>37</b> |
| <b>8.0 APPENDIX.....</b>                    | <b>40</b> |

## LIST OF TABLES

|                                                                                                                                                                                                                                                                                  |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Table 1. Determination of the suitability of locations for habitat analyses at different spatial scales. ☉ denotes scale for which the location is appropriate for habitat analysis.....                                                                                         | 10 |
| Table 2. Dates of capture and immobilisation of fishers during 1998-99, Williston Fisher Inventory Project. Ages were estimated from either palpitation of the sagittal crest (adult or juvenile) or from cementum annuli analysis (age in years). F01 was not radio-tagged..... | 13 |
| Table 3. Summary of independent locations collected for radio-tagged fishers during 1998-99, Williston Fisher Inventory Project.....                                                                                                                                             | 13 |
| Table 4. Frequency of location by season of radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Winter: 15 November to 31 March; Summer (including rearing): 1 April to 15 August; and Autumn: 16 August to 14 November.....                                | 15 |
| Table 5. Annual home range and core area estimates for radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Seven fishers (F08, FH, F12, F13, F14, F15, F30) were not included because of insufficient data ( $n < 7$ ).....                                 | 16 |
| Table 6. Seasonal home ranges and core areas for radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Home ranges could not be estimated for autumn because of insufficient sample sizes.....                                                                | 18 |
| Table 7. Precision of 440 locations of radio-tagged fishers collected during 1996-99, Williston Fisher Inventory Project.....                                                                                                                                                    | 20 |
| Table 8. Element-scale locations of radio-tagged fishers collected during 1997-99, Williston Fisher Inventory Project.....                                                                                                                                                       | 22 |
| Table 9. Characteristics of natal and maternal dens used by radio-tagged female fishers during 1997 and 1998, Williston Fisher Inventory Project. F02 used 2 cavities in her 1998 natal den tree as well as 2 different maternal den trees during the same year.....             | 23 |

## LIST OF FIGURES

|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Figure 1. Location of the study area and biogeoclimatic subzones. The study area is comprised entirely of the SBSmk and SBSwk subzones (hatched area). The solid line is the study area boundary.....                                                                                                                                                                                                                                           | 3  |
| Figure 2. Distribution of location times of radio-tagged fishers from ground and aerial telemetry performed during 1998-99, Williston Fisher Inventory Project. The majority of locations were collected between 09:01 and 15:00. $n = 401$ locations.....                                                                                                                                                                                      | 15 |
| Figure 3. Annual home ranges of radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Boundaries of home ranges are 95% isopleths of the utilisation distribution generated using a fixed kernel estimator. Approximate scale 1:562,000.....                                                                                                                                                                                 | 17 |
| Figure 4. Leading tree species of stands used by radio-tagged fishers, as recorded on aerial telemetry flights during 1996-98, Williston Fisher Inventory Project, $n = 249$ locations.....                                                                                                                                                                                                                                                     | 20 |
| Figure 5. Den attentiveness of F02 to her natal and maternal dens during 1998, Williston Fisher Inventory Project. We used a remote video camera, still cameras, and telemetry to monitor den attentiveness of F02. Times for which there are no bars represent intervals during which data was not collected. The power supply ran out between downloads on 29 April and 12 May, so the data that was collected during this time was lost..... | 25 |
| Figure 6. Den attentiveness of F04 to her natal den during 1998, Williston Fisher Inventory Project. We used a telemetry data logger, remote still cameras, and ground and aerial telemetry to monitor den attentiveness of F04. Times for which there are no bars represent intervals during which data was not collected.....                                                                                                                 | 26 |
| Figure 7. Den attentiveness of F09 to her natal den during 1998, Williston Fisher Inventory Project. We used remote still cameras and ground and aerial telemetry to monitor den attentiveness of F09. Times for which there are no bars represent intervals during which data was not collected.....                                                                                                                                           | 27 |



## 1.0 INTRODUCTION

The fisher (*Martes pennanti*) is a medium-sized member of the Mustelidae (weasel) family that inhabits much of the lowland forested area that dominates the plateau of north-central British Columbia. Although much of this landscape supported viable populations of fishers in the past, harvests have declined recently. Several factors may have contributed to this decline.

Fishers are considered to be habitat specialists, fulfilling most of their life requirements in forested habitats (Powell 1982, Weir 1995). Evidence from studies of fishers in western coniferous forests indicates that fishers require late-successional seral stages or structural features for foraging, resting, and whelping (Jones 1991, Weir 1995). Because of this association with late-successional forests, forest harvesting activities that focus on late-successional forests can have detrimental effects on fisher populations by altering and degrading the abundance and distribution of the resources that they require.

Aside from the potential effects of forest harvesting, fisher populations are also negatively affected by humans through fur harvesting activities. Fishers are identified as furbearers under the British Columbia Wildlife Act and are trapped for their pelts, despite their populations being considered "vulnerable" (blue-list) by the provincial Conservation Data Centre. Fishers are also classified by the Wildlife Branch of the Ministry of Environment, Lands and Parks as Class 2 furbearers because they are susceptible to overharvest, their populations occur at low densities, and home ranges of individual fishers can span more than one trapline (Banci 1989). Although fisher pelts are valuable relative to other furbearing mammals, the majority of the harvest of fishers in British Columbia is the result of incidental captures in traps set for martens (*Martes americana*).

The broad goal of this study is to collect information to facilitate management of fishers and their habitat in the industrial landscapes of northern British Columbia. The objectives for the third year of this project were to continue to monitor the home ranges, movements, and habitat use of fishers in a representative forest landscape of sub-boreal forests in north-central British Columbia. Specific objectives were to collect additional locations on tagged fishers, identify natal and maternal dens of fishers, examine the productivity of female fishers, assess dispersal movements of juvenile fishers, identify resting sites, and capture and tag new individuals and fishers with malfunctioned radiocollars.

Funding for this project was provided by the Operational Inventory Program Portfolio of Forest Renewal British Columbia (Project # OP96-220) and the Peace/Williston Fish and Wildlife Compensation Program, a joint venture between BC Hydro and the British Columbia Ministry of Environment, Lands and Parks. Partners in this inventory program were the Peace/Williston Fish and Wildlife Compensation Program, the BC Ministry of Environment, Lands and Parks, Finlay Forest Industries Ltd., the Slocan Group, and the British Columbia Trapper's Association. The project was conducted co-operatively with the Northern Wolverine Study (Forest Renewal British Columbia Project # OP97-078), whose personnel assisted in the collection of trapping data. F. Corbould administered project funds, assisted in the field, and provided reviews of drafts of this document. A. Bowser, J. McCormick, and V. Hawkes helped monitor traps, radio-tag fishers and wolverines, perform radiotelemetry, and enter data. M. McAdie, DVM performed the surgery to tag fishers with intraperitoneal transmitters. R. Critchlow scaled the den trees and measured characteristics of the natal and maternal dens. Members of the Peace/Williston Fish and Wildlife Compensation Program Technical Committee provided helpful comments on earlier drafts of this report.

## 2.0 STUDY AREA

The study area covers approximately 2,160 km<sup>2</sup> and is centred 70 km north-west of Mackenzie, British Columbia (Fig. 1). The entire area is within the Peace River drainage. All watersheds within the study area drain into the Williston Reservoir. The major watersheds in which the study is occurring are the Manson, Omineca, and Mesilinka Rivers. The study area is bounded by Williston Reservoir to the east, Nation River to the south, the Wolverine and Swannell Ranges to the west, and the bend in the Mesilinka River (south of Carina Lake) and Mica Creek to the north.

The study area is located entirely within the Mackenzie Forest District of the Prince George Forest Region and lies within the Sub-Boreal Interior ecoprovince, Omineca Mountains ecoregion, and Parsnip Trench, Southern Omineca Mountains, and Manson Plateau ecosections (Demarchi 1995). The boundary of the study area is defined by the extent of the Sub-Boreal Spruce (SBS) biogeoclimatic zone that occurs in this region. The topography of the study area is characterised by a gently rolling plateau rising from the Rocky Mountain Trench (Williston Reservoir) in the east to the slopes of the Wolverine and Swannell Ranges in the west. The plateau is drained by a series of small

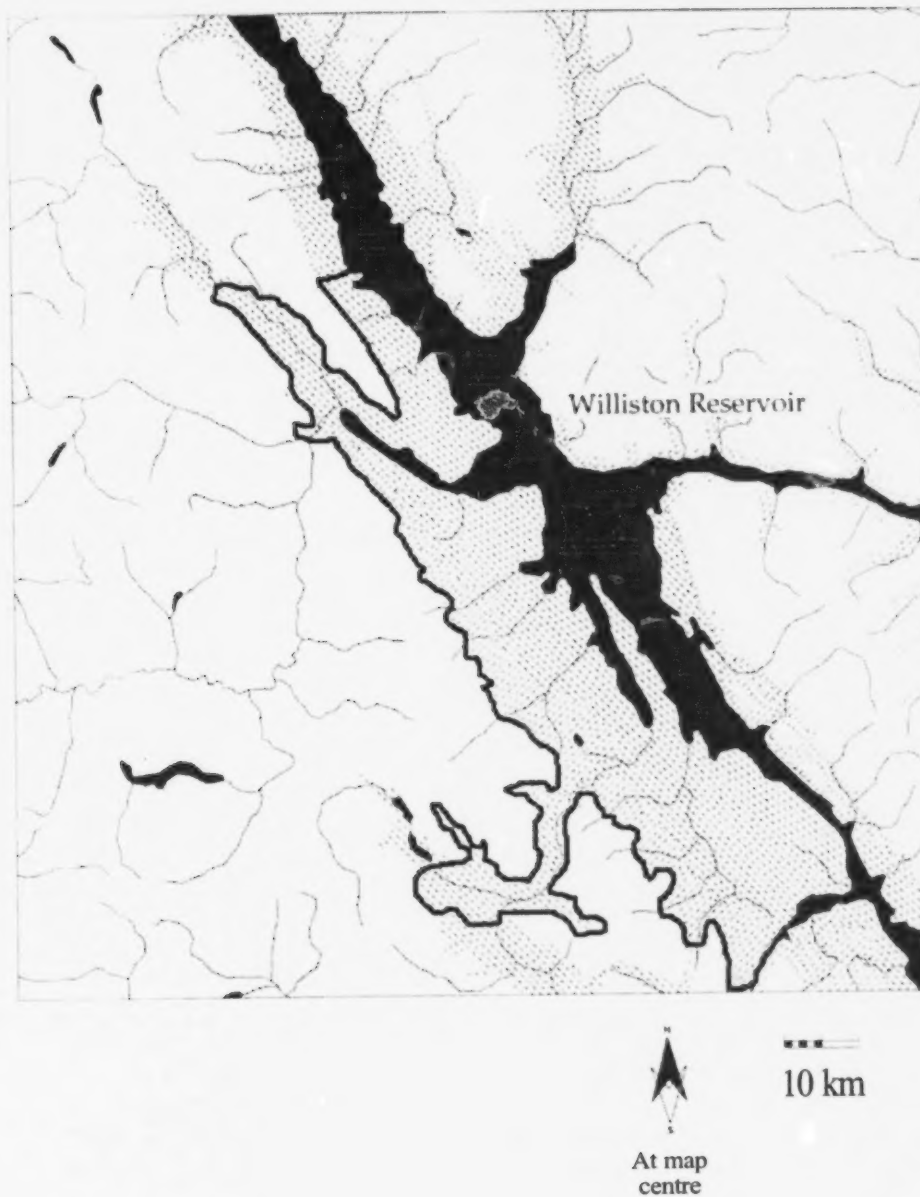


Figure 1. Location of the study area and biogeoclimatic subzones. The study area is comprised entirely of the SBSmk and SBSwk subzones (hatched area). The solid line is the study area boundary.

creeks with poorly developed or non-existent floodplains. Floodplains with extensive riparian zones exist on only three major rivers: the Manson, Omineca, and Mesilinka Rivers.

The study area is comprised of two subzones of the SBS. At elevations below 800 m, the moist cool subzone (SBSmk) of the SBS occurs, while between 800 and 1100 m, the wet cool subzone (SBSwk) occurs (MacKinnon *et al.* 1990). The SBSmk comprises the majority of the study area, covering approximately 80% of the area. Annual precipitation in the SBSmk is 690 mm and 905 mm in the SBSwk (MacKinnon *et al.* 1990). Snowfall in the SBSmk is 335 cm/year and 1075 cm/year in the SBSwk (MacKinnon *et al.* 1990). Snow cover in the study area generally lasts from November until April.

Forests in the SBSmk are dominated by hybrid spruce (*Picea glauca* x *engelmannii*), lodgepole pine (*Pinus contorta*), black spruce (*Picea mariana*), and subalpine fir (*Abies lasiocarpa*), with deciduous components of trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*). Black cottonwoods (*Populus balsamifera* spp. *trichocarpa*) occur as a minor element in riparian-type ecosystems and occasionally in other areas with sub-hygic or wetter ecological moisture regimes. The composition of forests in the SBSwk is similar, with hybrid spruce and subalpine fir being more dominant.

Disturbances in the SBSmk and SBSwk follow a typical pattern. The principal natural disturbance factors in these ecosystems are fire and insect outbreaks (MacKinnon *et al.* 1990). Young forest stages are comprised primarily of lodgepole pine, while later successional stands are dominated by spruce and subalpine fir. The SBSmk has a natural disturbance regime of frequent, large-scale burns (up to 100,000 ha) occurring about every 125 years, while the ecosystems in the SBSwk portion of the study area are exposed to moderate-sized burns (20 to 1,000 ha) with a fire cycle of about 200 years (British Columbia Ministry of Forests and British Columbia Ministry of Environment, Lands and Parks 1995).

Human-caused disturbance in the study area is extensive. With the flooding of the Williston Reservoir in 1968-72, many of the valley bottom riparian forests in the area were submerged, mostly in the lower Omineca, Manson, and Parsnip Rivers. Forest harvesting, primarily of mature and late-successional stands, has occurred throughout the study area over the past 25 years. Forest harvesting and natural disturbances have resulted in a mosaic of seral stages and stand types throughout the study area.

The study area encompasses five registered fur harvesting traplines. Traplines in the northern portion of the study area include 738T009,

which is located primarily on the Mesilinka River, and 738T010, which occupies the Chunamon Creek/Raspberry Harbour area. Trapline 729T005 runs from km 155 on the Finlay Forest Service Road south beyond the Manson River. Trapline 728T007 occurs on the Manson River drainage west of the Carmella Creek and 729T004 occupies the Blackwater Creek area.

### 3.0 METHODS

#### 3.1 Capturing

We attempted to capture fishers to radio-tag new animals and replace malfunctioned and expiring transmitters on previously-tagged individuals. We used four types of live-trap sets to capture fishers: barrel, log-cabin, Havahart collapsible, and Havahart permanent. We set primarily Havahart permanent traps (Model 1081), which were wire-mesh sets approximately 24.5 x 31 x 81 cm. Havahart collapsible traps (Model 1089) were similar in dimensions to the permanent type, but collapsed for storage by the back door folding out and the sides of the trap folding inward. We also set and monitored several log-cabin and barrel traps that were intended primarily for wolverines (*Gulo gulo*). The log-cabin sets were made of intermeshing logs, with a trigger mechanism that released a log door when a bait was pulled from inside the trap (Krebs 1993). Barrel traps consisted of a 45 gallon drum with a sliding door cut into one end (Banci 1987), similar in design to culvert traps used to capture bears. Log-cabin traps were immobile, while barrel and Havahart traps were portable.

We set traps to ensure that animals remained dry, insulated, and had a supply of food while trapped. We placed the Havahart traps on beds of hybrid spruce or subalpine fir boughs and covered the top, sides, and bottom of the traps with disassembled waterproof cardboard boxes (tree planting boxes). Traps were lined with straw and covered with more boughs so that snow or wind did not penetrate the trap. We also added straw to the interior of barrel and log-cabin traps. We usually baited each Havahart trap with approximately 500 g of moose meat, but occasionally used grouse and duck carcasses for bait. Log-cabin and barrel traps were baited with pieces of moose carcass (1.5 - 3 kg).

We took several actions to enhance the efficacy of the traps. At each trap site, nearby vegetation was scented with a combination of commercial fisher, marten, and beaver lure, and skunk oil. Scent was re-applied every 3-5 days. Prior to setting the trap for the first time, the

pan, cable, and door of each trap were lubricated with petroleum jelly and tested to ensure that the trap functioned properly.

We checked traps daily and assessed the functioning of each trap every 2-3 days. We considered trap nights during which the trap malfunctioned (i.e., blocked, tripped, escape, or no bait) as partial trap nights (0.5 trap night). When we captured non-target species in the traps, we fed them a small amount of strawberry jam (to reduce likelihood of hypoglycaemia) and released them immediately. We closed and removed traps at locations where martens were captured on more than 5 consecutive nights.

We recorded maximum and minimum temperatures, as well as snow depths, on a daily basis at various locations throughout the study area. Thermometers and snow stations were placed under normal forest canopy at least 10 m from the forest edge. We calculated mean daily temperatures and mean snow depths using data collected from each of these stations.

### 3.2 Immobilisation and Tagging

Prior to immobilisation, we estimated the body weight of each fisher to ensure that animals were administered appropriate dosages of anaesthetic. We used a handling cone to restrain the animal and administered drugs with a hand-held syringe for fishers captured in Havahart traps. We injected anaesthetic to fishers in log-cabin traps using a jab-stick.

Fishers were immobilised using a 1:1 mixture of tiletamine hydrochloride:zolazepam hydrochloride (Telazol®). We attempted to administer Telazol® at 8 mg/kg for untagged fishers and 5 mg/kg for animals that required limited handling (e.g., replacing transmitters). Because of the dramatic decreases in body temperature that we observed during immobilisations in the first year of our study (Weir 1997), we placed the immobilised fishers in a sternal position over warm hot-water bottles.

We measured and monitored fishers while they were immobilised. Sex, body weight, and cranial and skeletal measurements were documented. We also collected hair samples from each fisher. We classed most fishers as adults or juvenile by palpating the sagittal crest and examining the level of tooth wear (Powell 1982). For healthy fishers that were difficult to age using this technique, we removed a premolar 1 tooth for cementum annuli analysis (Strickland *et al.* 1982). Photographs were taken of the head, dorsal, and ventral regions. Respiration and

cardiac rate, body temperature, and capillary refill time were also recorded at regular intervals while the fishers were immobilised.

Each fisher was fitted with a radiocollar (Telonics® MOD-080) with a rot-away spacer and tattooed in the groin area with an individual identification number. We switched to using intraperitoneal (IP) implant transmitters (Telonics® IMP/300/L) for fishers caught after November 19, 1998.

To maintain anaesthesia for the implant surgery, a mask was placed over the animal's face and a mixture of isoflurane (Aerrane®) and oxygen was administered, delivered by a portable vaporiser. The concentration of Aerrane® was initially 3% for induction and 1-2% for maintenance of anaesthesia.

A routine surgical preparation of the ventral midline was performed following hair removal, which was limited to an approximately 3 cm by 5 cm area to minimise heat loss after release. A skin incision was made caudal to the umbilicus. Subcutaneous tissue was bluntly dissected and the incision continued through the linea alba. The implant was then inserted into the abdominal cavity and tucked around the body wall, adjacent to the right kidney, dorsal to the intestines. The abdomen was closed with 3-0 absorbable suture materials. The incision was sealed with a skin glue (Vetbond®) and the animal allowed to recover.

Following the immobilisation procedure, we placed each fisher back in the live trap wrapped in a blanket to recover from anaesthesia and to reduce the likelihood of hypothermia. We released the fishers from cages when they were fully recovered from the effects of the anaesthetic.

### 3.3 Radiotelemetry Monitoring

We located fishers using standard ground and aerial telemetry procedures (Weir 1995). Fishers were located from the air using Cessna 182 aircraft with two bi-directional H-antennae mounted on the wing struts. For each aerial telemetry location, we recorded the coordinates, time, site characteristics, overstory composition, and estimated precision of the location. From the ground, we recorded directional bearings from permanent ground stations to fishers using a three-element, collapsible Yagi antenna. We estimated locations and 95% error polygons from ground telemetry using Locate II software (Nams 1991). We estimated the precision of each location subjectively for aerial locations and used 95% error polygons for ground locations. We then classified each location into one of six precision categories:  $\pm <1$  m,  $\pm 1-30$  m,  $\pm 31-50$  m,  $\pm 51-100$  m,  $\pm 101-250$  m, and  $\pm >250$  m. We

assigned capture locations to the least precise category because of the potential bias of this data.

We located fishers once per week from the air and whenever possible from the ground. Coordinates from aerial locations were initially estimated using an on-board global positioning system (GPS). Coordinates were collected as latitude and longitude with a GPS unit and plotted on 1:20,000 forest cover maps as Universal Transverse Mercator (UTM) coordinates. We converted latitude and longitude coordinates into UTM coordinates for analyses using UTM conversion software (Geological Survey of Canada 1988). Aerial locations were error-checked with 1:15,000 or 1:40,000 air photographs. All ground telemetry work used UTM coordinates from 1:20,000 forest cover maps. All locations were recorded using North American Datum 1927.

We classified each location into one of three seasons for future home range and habitat use analysis. We defined the seasons as follows: winter: 15 November to 31 March; summer (including rearing): 1 April to 15 August; and autumn: 16 August to 14 November. We considered locations to be sufficiently independent for home range and habitat use analyses if they were separated by at least 16 hours. We did not consider repeated locations at traps or natal dens to be sufficiently independent for home range and habitat use analyses.

### 3.4 Home Range and Movements

We estimated the size and location of the home range of each resident fisher using two estimators. For fishers with more than 25 locations, we estimated home ranges using the 90% isopleth of the utilisation distribution (UD) generated from the fixed kernel method (Worton 1989). We calculated the core area of each home range using the 50% isopleth of the same distribution. To allow comparison with other studies, we also calculated home ranges using the 95% minimum convex polygon (MCP; Mohr 1947) method for fishers with more than 15 locations. For fishers with 15 or fewer locations, we used the 100% MCP method to calculate the total area over which we recorded locations. We excluded multiple observations of fishers at the same location (e.g., traps, dens) from home range calculations because inclusion of these data resulted in skewed estimates of the UD. We used The Home Ranger software (Hovey 1998) for the kernel home range calculations and CALHOME (Kie *et al.* 1994) software for the MCP calculations.

We calculated annual and seasonal home ranges for each fisher for which we had sufficient data. We pooled locations across years for each fisher for the calculation of their annual home range. We estimated

seasonal home ranges from data collected within one season (across multiple years) for each fisher.

### 3.5 Habitat Use

There are four spatial scales at which habitat use patterns may be analysed. These scales are nested and range from fine scale (element) to coarse scale (landscape). We considered each location for its suitability for inclusion in habitat analyses at 4 different spatial scales: element, patch, stand, and landscape. *Elements* are single structural features of habitat such as a piece of coarse woody debris or a large tree. *Patches* consist of assemblages of habitat elements and range in area up to 0.3 hectares. *Stands* are composed of patches and vary from 1.5 ha to hundreds of hectares. The *landscape* is composed of stands and is defined as the boundary of our study area (i.e., Sub-Boreal Spruce biogeoclimatic zone).

Each location is suitable for use in habitat analyses at different spatial scales, depending on its level of precision. Precise locations are suitable for inclusion in analyses at fine spatial scales (e.g., element scale), while less precise locations are only suitable for coarser-scale analyses (e.g., landscape scale). For example, the location of a fisher at a resting site could be used as data for habitat analysis at all four spatial scales. Because we know the element it was using, we also know which patch it was using, along with which stand and point in the landscape. However, with less precise locations, such as a ground telemetry location with an error polygon of 1.5 ha, we could only identify which stand and point in the landscape was used by the fisher. Thus, more precise locations are appropriate for habitat analyses at the finest scale up to the coarsest scale, while imprecise locations preclude use for analyses at all but the coarsest scales. We classified each location for its suitability for habitat analyses to the following categories based upon its precision: element, patch, stand, and landscape (home range) (Table 1).

During radiotelemetry monitoring, we limited the collection of habitat descriptions to the element spatial scale (i.e., structural elements used for rearing young or resting). We did not collect complete habitat information at the patch, stand, or landscape scale. However, during aerial telemetry flights, we did classify the stand used by the fisher based upon the dominant species of the overstory. Each stand was classified into one of the following categories: black cottonwood, trembling aspen, other deciduous (paper birch, willow [*Salix* spp.], or

Table 1. Determination of the suitability of locations for habitat analyses at different spatial scales, \* denotes scale for which the location is appropriate for habitat analysis.

| Precision of location | Error area    | Spatial scale |       |       |           |
|-----------------------|---------------|---------------|-------|-------|-----------|
|                       |               | Element       | Patch | Stand | Landscape |
| ± <1 m                | none          | *             | *     | *     | *         |
| ± 1-30 m              | < 0.3 ha      |               | *     | *     | *         |
| ± 31-50 m             | 0.3 - 0.8 ha  |               |       | *     | *         |
| ± 51-100 m            | 0.8 - 3.0 ha  |               |       | *     | *         |
| ± 101-250 m           | 3.0 - 19.6 ha |               |       |       | *         |
| ± >250 m              | > 19.6 ha     |               |       |       | *         |

alder [*Alnus* spp.]), hybrid spruce, black spruce, lodgepole pine, subalpine fir, regenerating clearcuts or burns (5 - 30 years old), and open or otherwise recently disturbed areas.

At the element scale, we collected specific information about the elements used by fishers. We classified the use of each element into three types: natal den, maternal den, and resting site. Natal dens were those structures used by female fishers for whelping. Maternal dens were those structures used in weeks following abandonment of the natal den by the female and kits (i.e., second rearing den). Resting sites were elements that were used for temporary resting by female fishers without their kits and male fishers through all seasons.

We measured several structural features of each element that was used by radio-tagged fishers for natal and maternal dens. We recorded the species of tree, diameter-at-breast-height (dbh), and height and type of element used. We also measured the diameter at den height and the dimensions of the den entrance and chamber. Chamber width and depth were measured just below the rim of the den entrance, while the chamber height was measured as the distance between the base of the cavity and the rim of the den entrance. We compared the aspect of the den entrances to a uniform distribution using Rayleigh's test (Zar 1984:442) and set the acceptable Type I error rate to 0.05.

We identified the elements used by active fishers during winter by homing in on a radiotransmitter, locating the fisher's tracks, and backtracking 50 m. At this point, we noted the element that the fisher was walking upon (if any) and flagged the site so that we could return during snow-free periods to measure the attribute.

### 3.6 Reproduction

We attempted to locate and monitor female fishers that gave birth to kits during the rearing season (April - June). We considered females to have whelped when we repeatedly located them using the same structural element over several weeks (*sensu* Paragi 1990, Powell *et al.* 1997).

We used several monitoring techniques to assess den attentiveness of females with kits during the rearing season. We monitored radio-tagged females for periods of up to 10 hours on several occasions using normal ground telemetry methods. We also set up a continuously-monitoring radiotelemetry data logger (Lotek SRX\_400 with W/16 option) at a selected den to determine the times that the female was at her den. The data logger was set to record the presence or absence of the female's radiotransmitter within a radius of less than 50 m at 15 minute intervals.

We also attempted to use two non-telemetry methods to assess den attentiveness and productivity of the female fishers with kits. We set up a remote-sensing video camera (Compu-Tech Systems® RM-680) and still cameras (TrailMaster® TM35) with both passive (TM1500) and active (TM500) infra-red sensors at each natal and maternal den. For both of these systems, we trained the infra-red sensors on the bole of the den tree, about 2.5 m above ground level, so that movement on the bole would cause the cameras to activate. The cameras were set up so that the date and time of activation were recorded on the respective media. Additionally, we established the camera sets in an effort to determine the number of kits that each female was rearing.

We assessed den attentiveness by collating continuous data from the ground monitoring sessions, telemetry data logger, and camera sets with point data collected from aerial and ground telemetry locations obtained during the rearing season.

## 4.0 RESULTS<sup>1</sup>

The data included in this report varies by section. Data reported in sections 4.1 *Captures*, 4.2 *Immobilisation and Tagging*, 4.3 *Radiotelemetry Monitoring*, 4.4 *Mortalities*, and 4.7 *Reproduction* is limited to that collected during the 1998-99 fiscal year. Sections 4.5 *Home Range and Movements* and 4.6 *Habitat Use* include all data collected since November 1996.

<sup>1</sup> Includes data up to 29 January 1999. Data collected after this date were not included because of timelines for production of this report.

#### 4.1 Captures

We had 16 captures of 8 fishers during 1,412.5 trap nights (1.13 captures/100 trap nights) between 5 October and 25 November 1998. We had traps operational for 1114.5 trap nights in October and 298 trap nights in November. Between these two months, traps were operational at 103 different locations throughout the study area. We also caught martens (48 captures), squirrels (12 captures), and minks (9 captures). The capture rate of fishers was much higher in November (4.03 captures/100 trap nights) than in October (0.36 captures/100 trap nights). One fisher (F15) was caught 7 times between 14 and 25 November.

#### 4.2 Immobilisation and Tagging

We caught 5 female and 3 male fishers in the study area between 14 October and 25 November 1998 (Table 2). Of the 8 fishers that we caught, 3 were recaptures from previous years (F01, F02, F07), while the remaining 5 were previously untagged (F12, F14, F15, F17, F20).

We successfully radio-tagged 7 of the 8 fishers that we caught (6 radiocollars, 1 radioimplant). The collar on one of the recaptured male fishers (F01) was causing him serious difficulties (extensive build-up of necrotic tissue around collar) and was removed. The wounds underneath the collar were drained and treated by Dr. M. McAdie, DVM and F01 was released to allow his neck to heal. Fortunately, another fisher (F07) who had similar problems with her radiocollar the previous year was also recaptured. Her wounds were completely healed with only minor blemishes visible on her neck.

To ensure that this trauma did not occur again, we used an IP implant transmitter for radio-tagging F20. The operation proceeded well and F20 made a full recovery from the anaesthesia within 12 hours.

Two female fishers dropped their collars within 4 months following radio-collaring in March 1998. The cotton firehose spacer on the collars of both F02 and F04 rotted off during the first week of June 1998. Neither of the two males that were radio-collared during February and March 1998 lost their radiocollars; F01's spacer did not rot away even though the collar was causing him difficulties.

#### 4.3 Radiotelemetry Monitoring

We collected 126 locations of 11 radio-tagged fishers between 1 April 1998 and 29 January 1999, of which 99 were sufficiently independent for use in home range and habitat use analyses (Table 3). We obtained

Table 2. Dates of capture and immobilisation of fishers during 1998-99, Williston Fisher Inventory Project. Ages were estimated from either palpitation of the sagittal crest (adult or juvenile) or from cementum annuli analysis (age in years). F01 was not radio-tagged.

| ID  | Name     | Sex | Age      | Date trapped |
|-----|----------|-----|----------|--------------|
| F01 | Beau     | M   | Adult    | 16/11/98     |
| F02 | Patches  | F   | Adult    | 17/10/98     |
| F07 | Inka     | F   | Adult    | 14/11/98     |
| F12 | Penelope | F   | 1.5 yr   | 20/10/98     |
| F14 | Manson   | M   | 0.5 yr   | 22/10/98     |
| F15 | Jewel    | F   | Juvenile | 14/11/98     |
| F17 | Sensai   | F   | Unknown  | 09/11/98     |
| F20 | Fin      | M   | Adult    | 20/11/98     |

Table 3. Summary of independent locations collected for radio-tagged fishers during 1998-99, Williston Fisher Inventory Project.

| ID    | Name     | Date first collared | Aerial telemetry | Ground telemetry | Capture/mortality | Total |
|-------|----------|---------------------|------------------|------------------|-------------------|-------|
| F01   | Beau     | Jan 1997            | 12               | 6                | 1                 | 19    |
| F02   | Patches  | Nov 1996            | 3                | 12               | 1                 | 16    |
| F04   | Cali     | Nov 1996            | 1                | 13               | 0                 | 14    |
| F06   | Fester   | Mar 1998            | 13               | 2                | 0                 | 15    |
| F07   | Inka     | Feb 1997            | 2                | 1                | 2                 | 5     |
| F09   | Olsie    | Mar 1997            | 2                | 1                | 0                 | 3     |
| F12   | Penelope | Oct 1998            | 1                | 0                | 2                 | 3     |
| F14   | Manson   | Oct 1998            | 1                | 0                | 3                 | 4     |
| F15   | Jewel    | Nov 1998            | 1                | 2                | 1                 | 4     |
| F17   | Sensai   | Nov 1998            | 2                | 5                | 1                 | 8     |
| F20   | Fin      | Nov 1998            | 2                | 5                | 1                 | 8     |
| Total |          |                     | 40               | 47               | 12                | 99    |

these data through aerial telemetry, ground telemetry, captures, and mortality locations. We collected the majority of the locations between 9:00 and 15:00 in all years of the study (Fig. 2). We located fishers 32 times during winter, 44 times during summer, and 23 times during autumn (Table 4).

#### 4.4 Mortalities

At least 4 of the 11 fishers that we had radio-tagged died during 1998-99. F07 died during January 1999 from as-yet-undetermined causes, likely predation. F12 was killed in a C120 Magnum fur trap during early November 1998. In November 1998, F14 died in a log-cabin trap when he darted between the trap door and the side of the trap as the door was being lowered. We found F15 curled up in a ball underneath a large piece of coarse woody debris (CWD) in January 1999. She was a very small fisher (2.2 kg) and may have died from starvation.

In addition, we recorded F06's radiotransmitter indicating mortality during an aerial telemetry flight on 16 October 1998. However, on the subsequent site investigation, we were unable to locate any signals. Thus, we could not determine whether the mortality signal was caused by a malfunctioning radiotransmitter, spacer rot-away, or actual mortality. The distance over which the signal from the transmitter could be detected had declined substantially in previous months, so transmitter malfunction may have occurred. However, even if his radiotransmitter malfunctioned, we did not recapture F06 during 278 trap nights within his apparent home range during October 1998.

#### 4.5 Home Range and Movements

We estimated the annual and seasonal home ranges of several fishers from data collected between 18 November 1996 and 29 January 1999 (Table 5, Table 6). We estimated annual home ranges for 6 radio-tagged fishers (5 females, 1 male; Fig. 3). We also estimated seasonal home ranges for 6 fishers during summer and 1 fisher during winter (Table 6). We were unable to estimate home ranges for any fishers for the autumn season because of insufficient sample sizes.

The home range of the single male was larger than those of the female fishers. The mean annual 90% UD home range size for females was smaller than for the male ( $x_{\text{female}} = 43.9 \text{ km}^2$ ,  $\text{SE} = 11.4$ ,  $n = 5$ ; male =  $281.8 \text{ km}^2$ ). The mean annual core area of the females was also smaller than that of the male ( $x_{\text{female}} = 10.1 \text{ km}^2$ ,  $\text{SE} = 3.2$ ,  $n = 5$ ; male =  $60.1 \text{ km}^2$ ).

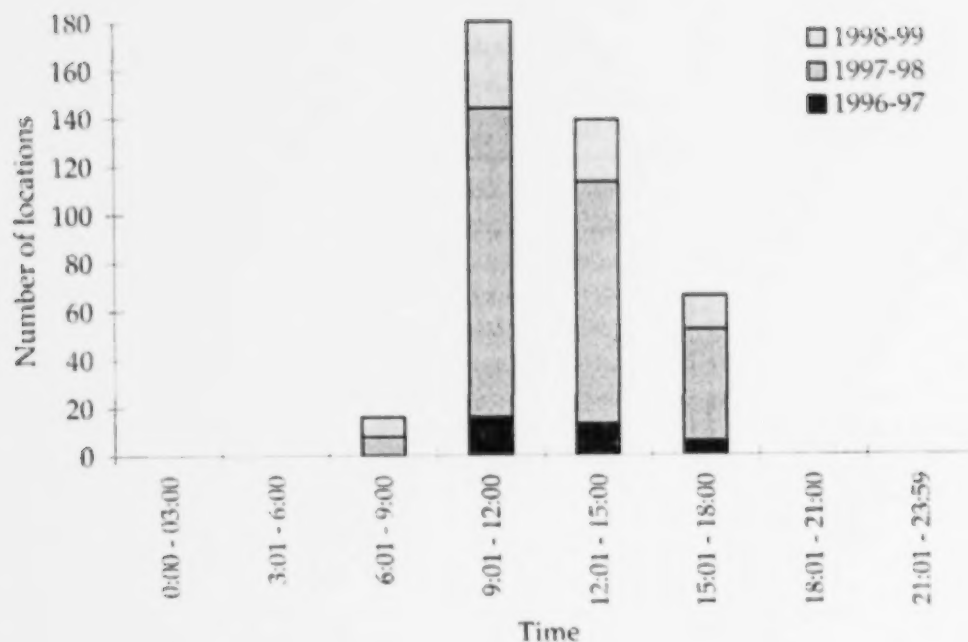


Figure 2. Distribution of location times of radio-tagged fishers from ground and aerial telemetry performed during 1998-99, Williston Fisher Inventory Project. The majority of locations were collected between 09:01 and 15:00.  $n = 401$  locations.

Table 4. Frequency of location by season of radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Winter: 15 November to 31 March; Summer (including rearing): 1 April to 15 August; and Autumn: 16 August to 14 November.

|        | 1996-97 | 1997-98 | 1998-99 | Total |
|--------|---------|---------|---------|-------|
| Winter | 48      | 81      | 32      | 161   |
| Summer | n/a     | 165     | 44      | 209   |
| Autumn | n/a     | 47      | 23      | 70    |
| Total  | 48      | 293     | 99      | 440   |

Table 5. Annual home range and core area estimates for radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Seven fishers (F08, F11, F12, F13, F14, F15, F30) were not included because of insufficient data ( $n < 7$ ).

| ID   | Name    | Sex | $n^a$           | Home range (km <sup>2</sup> ) |                     | Core area <sup>d</sup><br>(km <sup>2</sup> ) |
|------|---------|-----|-----------------|-------------------------------|---------------------|----------------------------------------------|
|      |         |     |                 | MCP <sup>b</sup>              | 90% UD <sup>c</sup> |                                              |
| F01  | Beau    | M   | 58              | 177.8                         | 281.8               | 60.1                                         |
| F02  | Patches | F   | 76              | 33.4                          | 30.6                | 5.7                                          |
| F03  | Amelia  | F   | 39              | 24.8                          |                     |                                              |
| F04  | Cali    | F   | 28              | 49.5                          | 21.6                | 3.9                                          |
| F05  | Solo    | F   | 38              | 42.1                          | 71.0                | 18.0                                         |
| F06  | Fester  | M   | 15 <sup>e</sup> | 45.6                          |                     |                                              |
| F07  | Inka    | F   | 51              | 30.0                          | 24.2                | 5.3                                          |
| F09  | Olsie   | F   | 59              | 54.6                          | 72.1                | 17.9                                         |
| F10  | Luci    | F   | 8 <sup>f</sup>  | 1237.0                        |                     |                                              |
| F16  | Frankie | F   | 7               | 10.2                          |                     |                                              |
| F17  | Sensai  | F   | 8               | 7.3                           |                     |                                              |
| F20  | Fin     | M   | 8               | 21.7                          |                     |                                              |
| F300 | Linnea  | F   | 8               | 15.6                          |                     |                                              |

<sup>a</sup> Includes all capture, mortality, aerial telemetry, and ground telemetry locations, except for multiple observations at the same location

<sup>b</sup> Minimum convex polygon method (95% MCP for animals with >15 locations, 100% MCP for  $\leq 15$  locations)

<sup>c</sup> Utilisation distribution estimated from fixed kernel method

<sup>d</sup> 50% utilisation distribution

<sup>e</sup> Locations following home range establishment

<sup>f</sup> Locations while dispersing

We observed several differences among seasonal home ranges (Table 6). Firstly, the size of the female (F02) home range for which we could calculate both winter and summer ranges decreased from winter (36.1 km<sup>2</sup>) to summer (11.2 km<sup>2</sup>). Secondly, the home ranges of females with kits was smaller ( $x_{\text{kits}} = 33.4$  km<sup>2</sup>, SE = 21.9,  $n = 4$ ) during the summer when compared to the lone female without kits (103.0 km<sup>2</sup>). Finally, reproducing females who had summer home ranges that included extensive floodplain ecosystems (F02, F03, F07) had smaller home ranges ( $x_{\text{FLP}} = 11.5$  km<sup>2</sup>, SE = 0.2,  $n = 3$ ) than the reproducing female whose summer home range did not include these ecosystems (F09; 99.1 km<sup>2</sup>).

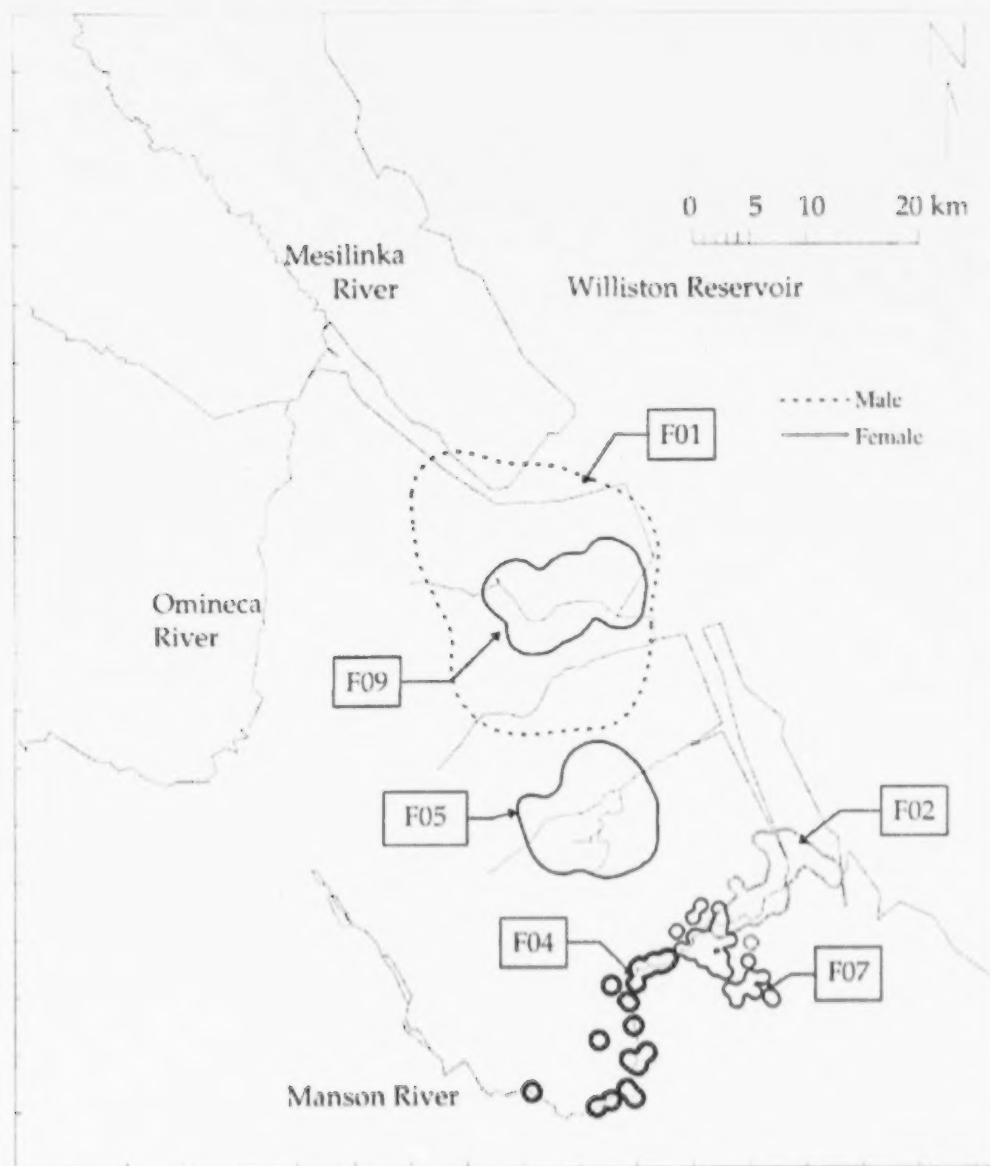


Figure 3. Annual home ranges of radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Boundaries of home ranges are 95% isopleths of the utilisation distribution generated using a fixed kernel estimator. Approximate scale 1:562,000.

Table 6. Seasonal home ranges and core areas for radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. Home ranges could not be estimated for autumn because of insufficient sample sizes.

| ID               | Name    | Sex | <i>n</i> <sup>a</sup> | Years      | Home range (km <sup>2</sup> ) |                     | Core area <sup>c</sup><br>(km2) |
|------------------|---------|-----|-----------------------|------------|-------------------------------|---------------------|---------------------------------|
|                  |         |     |                       |            | 95% MCP                       | 90% UD <sup>b</sup> |                                 |
| Winter           |         |     |                       |            |                               |                     |                                 |
| F01              | Beau    | M   | 21                    | 97, 98     | 97.0                          |                     |                                 |
| F02              | Patches | F   | 39                    | 97, 98, 99 | 29.8                          | 36.1                | 6.8                             |
| F04              | Cali    | F   | 16                    | 97, 98     | 76.1 <sup>d</sup>             |                     |                                 |
| F07              | Inka    | F   | 15                    | 97         | 25.9 <sup>d</sup>             |                     |                                 |
| F09              | Olsie   | F   | 23                    | 97, 98     | 34.9                          |                     |                                 |
| Summer           |         |     |                       |            |                               |                     |                                 |
| F01              | Beau    | M   | 30                    | 97, 98     | 153.6                         | 220.5               | 52.8                            |
| F02 <sup>e</sup> | Patches | F   | 26                    | 97, 98     | 18.0                          | 11.2                | 2.0                             |
| F03 <sup>e</sup> | Amelia  | F   | 33                    | 97         | 19.1                          | 11.3                | 2.7                             |
| F04 <sup>e</sup> | Cali    | F   | 16                    | 97, 98     | 33.1                          |                     |                                 |
| F05 <sup>f</sup> | Solo    | F   | 28                    | 97         | 40.6                          | 103.0               | 24.0                            |
| F07 <sup>e</sup> | Inka    | F   | 26                    | 97         | 12.1                          | 11.9                | 1.9                             |
| F09 <sup>e</sup> | Olsie   | F   | 27                    | 97, 98     | 39.7                          | 99.1                | 23.4                            |

<sup>a</sup> includes all capture, mortality, aerial telemetry, and ground telemetry locations, except for multiple observations at the same location

<sup>b</sup> Utilisation distribution estimated from fixed kernel method

<sup>c</sup> 50% utilisation distribution

<sup>d</sup> 100% MCP

<sup>e</sup> rearing kits

<sup>f</sup> without kits

We radio-tagged 6 juvenile fishers between November 1996 and January 1999: F06, F10, FH, F13, F14, and F15. However, we were unable to monitor the movements of 4 of the juveniles because of mortality (FH, F14, F15) or transmitter malfunction (F13).

We collected sufficient information on F06 and F10 to assess their dispersal patterns. We followed F10 for 2 months in late 1997. F10 was exhibiting signs of site fidelity before she died, which suggests that she had located a suitable area in which to establish a home range. During the 2 months that she was transient, F10 covered over 1,200 km<sup>2</sup>, travelled at least 132 km, and died 77 km from where she was captured.

During 1998, we followed F06 for 7 months (17 March - 16 October), during which he appeared to establish a home range. We collected 2 locations for him around his trap location before he moved 26 km to the south-east during the first week of April, where we consistently located

him in a 45.6 km<sup>2</sup> area until we lost radio contact with him. The centre of his new area was 20.0 km from where he was caught. F06 had covered 170 km<sup>2</sup> between March and the mid-October.

## 4.6 Habitat Use

We assigned 440 locations of fishers collected between 18 November 1996 and 29 January 1999 to one of six precision categories (Table 7). We collected 32 element-scale locations, 115 patch-scale locations, 234 stand-scale locations, and 440 landscape-scale locations.

Not all of these locations were suitable for habitat analysis because we did not collect a sufficient number of locations to perform home range analyses for several of the fishers before they died or we lost radio contact. Locations from these animals were therefore not considered for habitat examinations that require the estimation of home ranges (i.e., landscape- and stand-scale comparisons).

### 4.6.1 Landscape Scale

We determined the biogeoclimatic variant classification for 440 locations of 20 fishers from 18 November 1996 to 29 January 1999. We located fishers primarily in the moist-cool 2 variant of the SBS (SBSmk2: 305 of 440 locations, 69.3%), but also in the SBS wet-cool 1 variant (SBSwk1: 23.6%), SBS moist-cool 1 variant (SBSmkl: 3.6%), Boreal White and Black Spruce dry-cool 1 variant (BWBSdkl: 2.5%), and the Engelmann Spruce-Subalpine Fir moist-very cold 3 variant (ESSFmv3: 0.9%). Of the 440 landscape-scale locations, 338 were useable for the calculation of annual or seasonal home ranges for 8 fishers (Appendix 1).

### 4.6.2 Stand Scale

During aerial telemetry flights, we recorded the dominant tree species of 249 stands used by radio-tagged fishers from 25 November 1996 to 15 December 1998 (Fig. 4). We observed fishers primarily using stands that were dominated by hybrid spruce (84 of 249 locations; 33.7%) and areas regenerating from clearcuts or burns (5 - 30 years old; 30.1%). Fishers also used stands comprised mostly of lodgepole pine (17.3%), black cottonwood (9.2%), trembling aspen (3.6%), open or otherwise recently disturbed habitats (3.2%), other deciduous (1.6%), black spruce (0.8%), and subalpine fir (0.4%).

Not all aerial telemetry locations were suitable for stand-scale habitat analyses. Based upon the precision of each location, we collected 234

Table 7. Precision of 440 locations of radio-tagged fishers collected during 1996-99, Williston Fisher Inventory Project.

| Estimated precision | Error area   | Scale analysis <sup>a</sup> | 1996-97 | 1997-98 | 1998-99 | Total |
|---------------------|--------------|-----------------------------|---------|---------|---------|-------|
| ± <1 m              | none         | E, P, S, L                  | 0       | 14      | 18      | 32    |
| ± 1-30 m            | < 0.3 ha     | P, S, L                     | 10      | 66      | 7       | 83    |
| ± 30-50 m           | 0.3 - 0.8 ha | S, L                        | 0       | 67      | 6       | 73    |
| ± 50-100 m          | 0.8 - 3.0 ha | S, L                        | 0       | 25      | 21      | 46    |
| ± 100-250 m         | 3.0 -19.6 ha | L                           | 26      | 81      | 9       | 116   |
| ± >250 m            | > 19.6 ha    | L                           | 12      | 40      | 38      | 90    |

<sup>a</sup> E = element, P = patch, S = stand, L = landscape (home range)

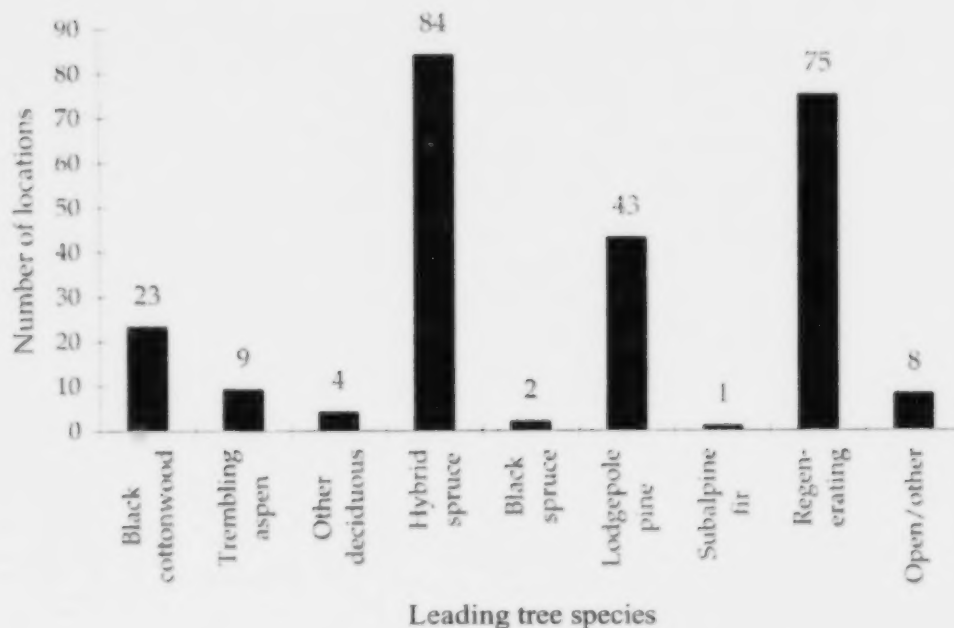


Figure 4. Leading tree species of stands used by radio-tagged fishers, as recorded on aerial telemetry flights during 1996-98, Williston Fisher Inventory Project,  $n = 249$  locations.

locations between 12 December 1996 and 24 January 1999 that were suitable for inclusion in stand-scale habitat analyses (Appendix 2). Of these, 173 may be used in stand-scale habitat analyses for 7 fishers.

#### 4.6.3 Patch Scale

We collected 115 locations for 14 fishers that were suitable for patch-scale habitat analyses between 12 December 1996 and 24 January 1999 (Appendix 3).

#### 4.6.4 Element Scale

Between 2 April 1997 and 24 January 1999, we recorded 32 locations of 11 radio-tagged fishers that were suitable for element-scale habitat analyses (Table 8). We recorded fishers using elements for resting most frequently (15 of 32). We also obtained element-scale locations for fishers while rearing kits (12 of 32) and active (3 of 32). We were unable to determine the activity of fishers at 2 element-scale locations (dropped collars). We recorded between 1 and 8 element-scale locations for each fisher.

We located fishers using several types of elements for resting (Table 8). We observed fishers resting on growths caused by spruce broom rust (*Chrysomyxa arctostaphyli*) in hybrid spruce trees at 5 locations. We also located fishers resting at 4 ground/slash-pile sites; in cavities of 2 black cottonwood and 1 trembling aspen trees; in or under single large pieces of CWD at 2 locations; and at one snow bed. We have not yet measured attributes of any of the elements used for resting by fishers.

We located tracks of active fishers at 3 locations. We identified the specific structural element being used by the fisher at only one of these locations; we noted F17 walking along the surface of a log on 14 November 1998. At the other 2 locations, the fisher was walking on top of the snow and did not appear to be using any specific structure.

We measured characteristics at each of the natal and maternal dens that we identified during the 1997 and 1998 rearing seasons. All of the elements selected by female fishers for rearing their kits were large diameter, declining black cottonwood or balsam poplar (*Populus balsamifera* ssp. *balsamifera*) trees (Table 9). The mean diameter of the black cottonwood trees ( $x_{dbh} = 112.1$  cm,  $SE = 7.1$ ,  $n = 11$ ) was larger than the one balsam poplar tree ( $dbh = 63.5$  cm). All of the den entrances were between 3 and 26 m above ground level ( $\bar{x} = 15.4$  m,  $SE = 2.0$ ,  $n = 12$ ). All of the entrances to the cavities were through holes

Table 8. Element-scale locations of radio-tagged fishers collected during 1997-99, Williston Fisher Inventory Project.

| ID    | Name    | Whelping |       |          | Resting |        |        |     | Unknown | Total |
|-------|---------|----------|-------|----------|---------|--------|--------|-----|---------|-------|
|       |         | Active   | Natal | Maternal | Bed     | Branch | Cavity | CWD | Ground  |       |
| F01   | Beau    |          | —     | —        |         | 1      |        |     |         | 1     |
| F02   | Patches |          | 1     | 2        |         | 1      | 2      | 2   |         | 8     |
| F03   | Amelia  |          | 1     | 1        |         | 1      |        |     | 1       | 4     |
| F04   | Cali    |          | 2     |          |         |        |        |     | 2       | 5     |
| F05   | Solo    |          |       |          |         | 1      |        |     |         | 1     |
| F07   | Inka    |          | 1     | 1        |         |        |        |     | 1       | 3     |
| F09   | Olsie   |          | 2     |          |         |        |        |     |         | 2     |
| F15   | Jewel   |          |       |          |         |        | 1      |     | 1       | 2     |
| F16   | Frankie |          | 1     |          |         |        |        |     |         | 1     |
| F17   | Sensai  | 1        |       |          |         | 1      |        |     |         | 2     |
| F20   | Fin     | 2        | —     | —        | 1       |        |        |     |         | 3     |
| Total |         | 3        | 8     | 4        | 1       | 5      | 3      | 2   | 4       | 32    |

Table 9. Characteristics of natal and maternal dens used by radio-tagged female fishers during 1997 and 1998, Williston Fisher Inventory Project. F02 used 2 cavities in her 1998 natal den tree as well as 2 different maternal den trees during the same year.

| ID            | Name    | Date first confirmed | Use - year              | Tree spp <sup>a</sup> | DBH (cm) | DDH <sup>b</sup> (cm) | Den height (m) | Den entrance |            |            | Den chamber |            |            |    |    |
|---------------|---------|----------------------|-------------------------|-----------------------|----------|-----------------------|----------------|--------------|------------|------------|-------------|------------|------------|----|----|
|               |         |                      |                         |                       |          |                       |                | height (cm)  | width (cm) | Aspect (°) | height (cm) | width (cm) | depth (cm) |    |    |
| Natal dens    |         |                      |                         |                       |          |                       |                |              |            |            |             |            |            |    |    |
| F03           | Amelia  | 16/04/97             | natal - 97              | Ac                    | 105      |                       |                |              |            |            |             |            |            |    |    |
| F04           | Cali    | 04/04/97             | natal - 97              | Ac                    | 87       | 89                    | 6              | 5            | 4          | 183        |             | 90         |            | 38 | 38 |
| F07           | Inka    | 02/04/97             | natal - 97              | Ac                    | 105      | 67                    | 10             | 7            | 8          | 110        |             | 203        |            | 20 | 20 |
| F09           | Olsie   | 03/04/97             | natal - 97              | Ac                    | 113      | 70                    | 16             | 10           | 13         | 135        |             | 190        |            | 32 | 32 |
| F16           | Frankie | 19/04/97             | natal - 97              | Ab                    | 63       | 56                    | 10             | 100          | 6          | 195        |             | 210        |            | 10 | 10 |
| F02           | Patches | 31/03/98             | natal - 98 <sup>c</sup> | Ac                    | 131      | 66                    | 19             | 9            | 8          | 250        |             | 290        |            | 50 | 50 |
|               |         |                      | natal - 98 <sup>d</sup> |                       |          | 66                    | 16             | 10           | 20         | 25         |             | 40         |            | 20 | 20 |
| F04           | Cali    | 06/04/98             | natal - 98              | Ac                    | 88       | 50                    | 21             | 9            | 5          | 2          |             | 440        |            | 16 | 16 |
| F09           | Olsie   | 01/04/98             | natal - 98              | Ac                    | 95       | 56                    | 26             | 8            | 8          | 337        |             | 280        |            | 35 | 35 |
| Maternal dens |         |                      |                         |                       |          |                       |                |              |            |            |             |            |            |    |    |
| F03           | Amelia  | 23/05/97             | maternal - 97           | Ac                    | 137      | 79                    | 20             | 20           | 19         | 140        |             | 10         |            | 40 | 20 |
| F07           | Inka    | 29/05/97             | maternal - 97           | Ac                    | 84       | 54                    | 20             | 13           | 10         | 210        |             | 335        |            | 10 | 30 |
| F02           | Patches | 15/05/98             | maternal - 98(1)        | Ac                    | 135      | 130                   | 3              | 74           | 5          | 205        |             | 800        |            | 70 | 10 |
| F02           | Patches | 07/06/98             | maternal - 98(2)        | Ac                    | 152      | 84                    | 18             | 7            | 9          | 167        |             | 90         |            | 9  | 9  |

<sup>a</sup> Ab = balsam poplar, Ac = black cottonwood

<sup>b</sup> diameter at den entrance

<sup>c</sup> natal cavity 1

<sup>d</sup> natal cavity 2

resulting from large branches breaking away from the bole or cracks into the heartwood. The mean date at which we recorded female fishers beginning to use natal dens was 8 April (range: 30 March - 19 April).

We climbed den trees and measured the characteristics of the natal and the maternal dens (Table 9). The mean diameter of the bole at the den entrance was 72.2 cm (SE = 6.3,  $n = 12$ ), while the mean diameter of the bole at the cavity bottom was 68.1 cm (SE = 4.4,  $n = 7$ ). The mean aspect of the entrances to the dens was  $174^\circ$  and was significantly different from random (Rayleigh's  $z = 198.07$ ,  $n = 12$ ,  $P < 0.001$ ). The mean dimensions of the den entrances were 22 cm in height (SE = 9,  $n = 12$ ) and 10 cm in width (SE = 2,  $n = 12$ ).

The chambers used by the females to house the kits were fairly similar among the natal and maternal dens. All of the cavities were cylindrical with relatively flat bottoms. The mean dimensions of the den chambers were 30 cm in width (SE = 6,  $n = 11$ ), 25 cm in depth (SE = 4,  $n = 11$ ), and 248 cm in height (SE = 62,  $n = 12$ ). The width and depth of the chambers were not necessarily consistent from the top of the chamber to the bottom; irregularities in the decay of the heartwood often changed the dimensions of the chamber cavity. The bottom of the chamber may not have always been used as the bed; at 2 of the dens, females appeared to have used platforms within the cavity. We did not observe any hair or faeces at the bottom of these chambers, although the walls of the chambers were extensively scratched.

#### 4.7 Reproduction

We monitored the attentiveness of 3 females (F02, F04, F09) to their kits during April and May 1998 (Figs. 5-7). Using a remote video camera, remote still cameras, ground and aerial telemetry, and a telemetry data logger, we determined den attentiveness of the 3 females for 11% of the denning period (447.5 of 4,072 hours). We monitored F04 for 210 of 1,095.75 denning hours (19.2%) using primarily a telemetry data logger, as well as some ground and aerial telemetry and remote still camera coverage. We would have collected more continuous data, but 2 weeks of data became corrupted on the data logger during early May. We collected 235.5 of 1,800 denning hours (12.4%) of coverage for F02 using a remote video camera, remote still cameras, and ground and aerial telemetry. We monitored F09 for only 1.2% of the time she was using her natal den (14 of 1,176.25 denning hours), using ground and aerial telemetry and remote still cameras.



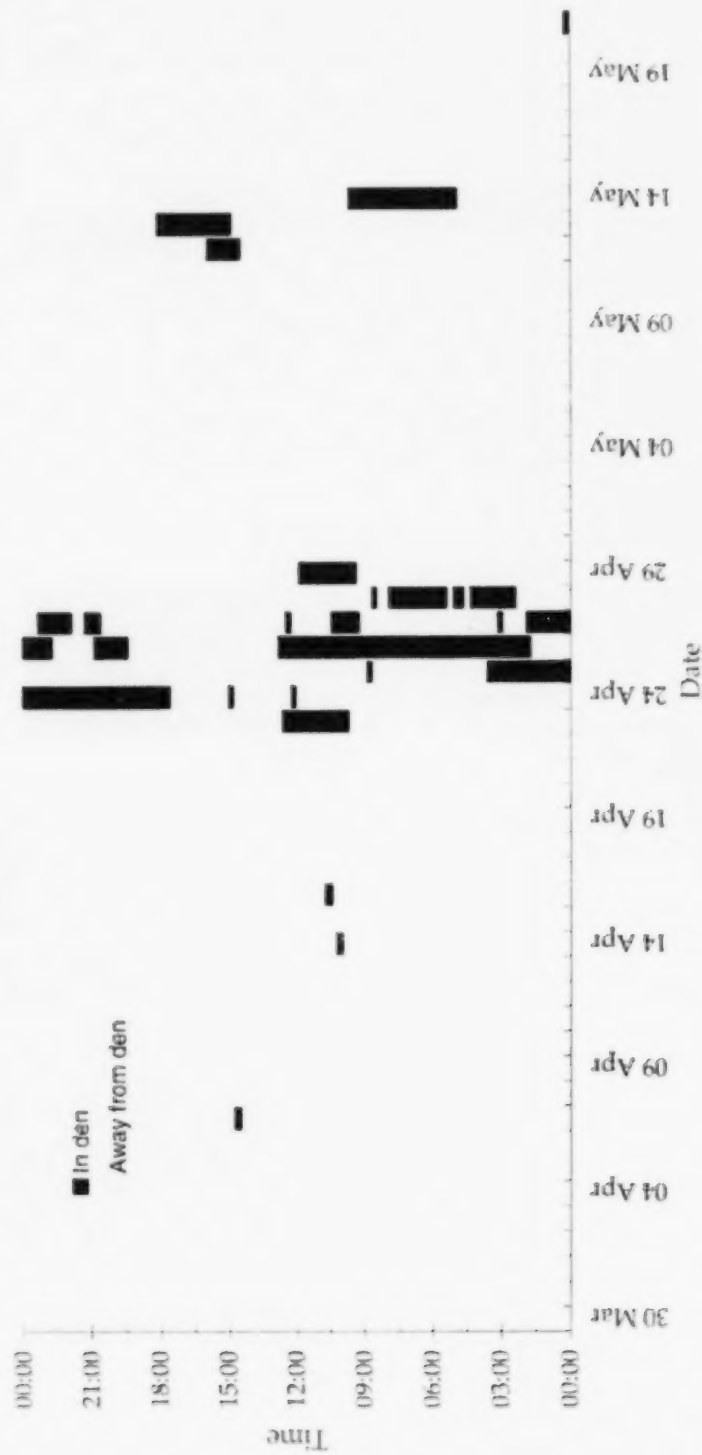


Figure 6. Den attentiveness of F04 to her natal den during 1998, Williston Fisher Inventory Project. We used a telemetry data logger, remote still cameras, and ground and aerial telemetry to monitor den attentiveness of F04. Times for which there are no bars represent intervals during which data was not collected.

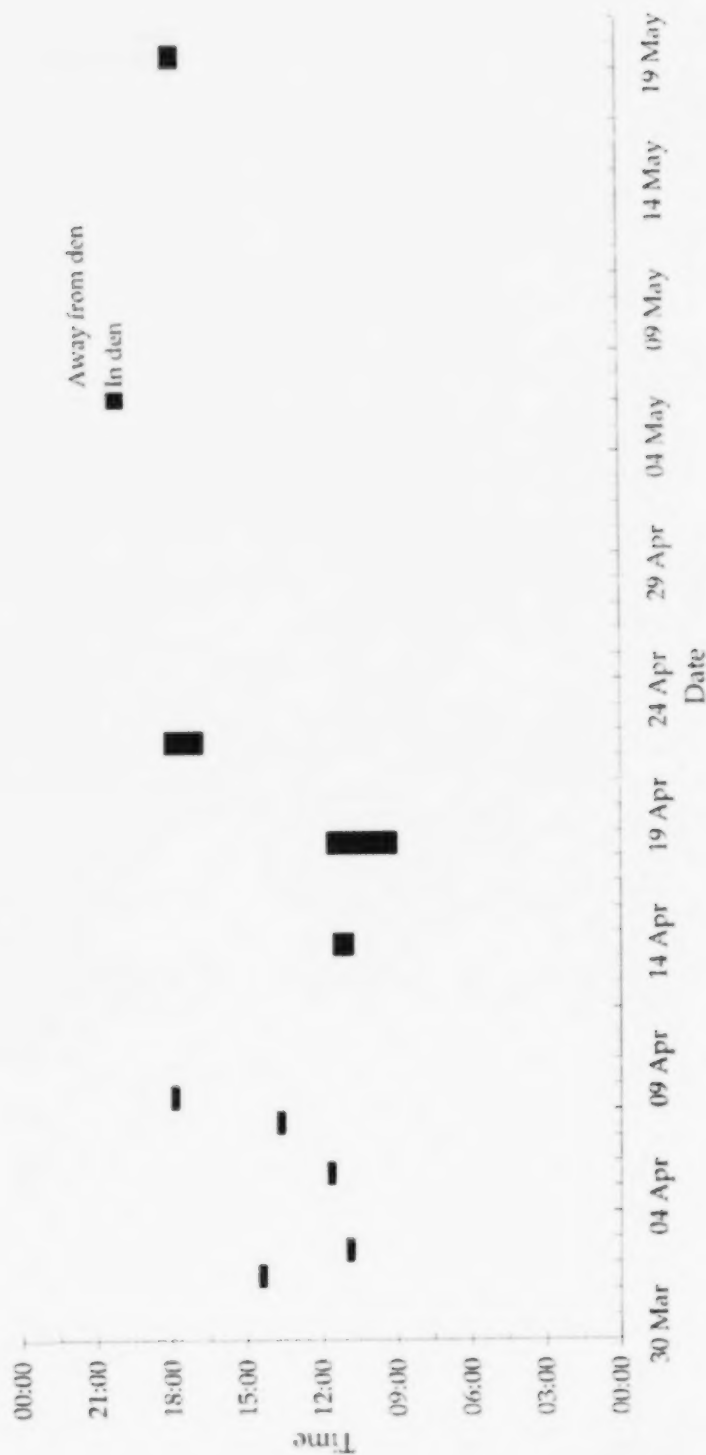


Figure 7. Den attentiveness of F09 to her natal den during 1998, Williston Fisher Inventory Project. We used remote still cameras and ground and aerial telemetry to monitor den attentiveness of F09. Times for which there are no bars represent intervals during which data was not collected.

Because of the paucity of monitoring data, we were unable to discern any consistent pattern of den attentiveness among the three females. However, a general trend of decreasing den fidelity as time since parturition increased seemed to be apparent. At the end of four weeks post partum, we were unable to consistently locate the fishers at their dens, indicating that they were spending increasing time away from their dens.

During the 1998 reproductive year, we recorded only one of the three females switching from a natal to maternal den (F02). Both F04 and F09 each used a single natal den for all of April and May. F02 switched to her first maternal den between 11 and 15 May (6 weeks post partum) and switched to her second maternal den sometime between 16 May and 7 June.

We did not obtain any photographs or video footage of the females carrying their kits away from their dens. Thus, we were unable to determine the productivity of the females.

## **5.0 DISCUSSION**

### **5.1 Capturing**

The capture rate that we observed in October and November 1998 was much higher than previous years. However, the highest capture rate was recorded in November, when we had the fewest traps operational, which translated into fewer captures.

Trapping for juveniles in October was not very successful. The capture rate was very low, despite having 92 traps continuously operational throughout the study area for a 3 week period. During this time, we caught 3 fishers, only one of which was a juvenile. Although juvenile fishers begin dispersing from their natal ranges during autumn (Arthur *et al.* 1993), fishers may have avoided our traps because of abundant prey elsewhere. If we allocate the same trapping effort to November (when fishers seem to be more vulnerable to trapping), we may be able to capture enough juveniles to examine dispersal.

### **5.2 Immobilisations and Tagging**

Similar to previous years, we experienced problems with radiocollars during 1998-99. Although transmitter units worked well and transmitted signals that allowed us to monitor the fishers, 2 of the 4 fishers that we had collared at the end of March 1998 had dropped their collars by the middle of June (F02, F04). The single-layer cotton firehose

spacer that we used did not last as long as anticipated. Subsequently, we modified our design for radiocollars that we put on fishers during autumn by adding an additional layer of firehose and stitching the firehose farther back into the webbing of the collar. We did not have any further episodes of advanced collar rot-away with the new design.

Although we used a collar with the single layer rot-away spacer, we discovered that F01's radiocollar was causing him serious difficulties. Even though the circumference of the collar that was affixed on 17 February 1998 was 3.5 cm greater than the circumference of his neck at the time, he accumulated muscle around his neck. Fortunately, a wildlife veterinarian was able to provide treatment for his wounds. Given that F07 had similar injuries and recovered fully, we hope that F01 will make a similar recovery. Because of this apparent danger, we decided to use IP implant transmitters for future radio-tagging.

### 5.3 Radiotelemetry Monitoring

The number of locations that we obtained for each radio-tagged fisher was less than expected during 1998-99, largely for two reasons. We allocated a large portion of our field effort to monitoring females with kits during April and May 1998. Consequently, we were unable to monitor the males (F01, F06) during this time. We also did not complete as many aerial telemetry flights during 1998-99 as during previous years because of financial constraints. Finally, we had fewer transmitter days (1 transmitter operational for 1 day) than previous years because of high mortality, the low number of tagged animals, and advanced collar rot-off.

To increase the number of locations that we collect for each fisher, several modifications to our tagging and monitoring methods need to occur. We need to reduce the amount of effort required to assess den attentiveness for females with kits during April and May. The most efficient method for monitoring females with kits appears to be through the use of telemetry data loggers at each den (see section 5.7 *Reproduction*), thus allowing field personnel to dedicate their time to locate other fishers. We also need to increase the number of transmitter days per individual, which will hopefully be achieved by the use of regular and duty cycle IP transmitters.

The one IP implant transmitter that we have operational (F20) appeared to work quite well. The range over which we detected signals tended to be about 2 - 4 km with ground telemetry and 5 - 8 km with aerial telemetry. This transmission distance was somewhat less than the Telonics radiocollars (4 - 8 km from ground), but was much farther than with the Holohil radiocollars that were used during 1996-97 (0.5 - 2 km

from ground). We have not had any difficulty locating F20 since he was initially tagged on 20 November 1998.

#### 5.4 Mortalities

Since 1996, we have confirmed that 9 of 20 study animals (45%) have died. Sources of mortality were fur trapping (3 fishers), starvation (2), predation (2), intraspecific attack (1), and live-trapping (1). An additional 2 study animals may also have died, but we were unable to validate the cause of their respective mortality signals (F05, F06). Also, at least 5 non-study animals have been harvested from within the study area. Future effort should be directed toward assessing survivorship rates from radiotelemetry data to help determine the vulnerability of the fisher population in a representative forest landscape.

#### 5.5 Home Range and Movements

The annual home ranges of the fishers in this study appear to be larger than those reported elsewhere in British Columbia. The mean annual home range size of female fishers in south-central British Columbia was reported to be 26.4 km<sup>2</sup> (Weir 1995), while the size of the home ranges of females in our study was roughly 67% larger (43.9 km<sup>2</sup>). The one male fisher that we monitored had a home range (281.8 km<sup>2</sup>) that was approximately 60% larger than the largest male home range reported elsewhere in British Columbia (summer home range, *Unpubl. data*). The reasons for the differences in size of home ranges between our study and that of Weir (1995) are unclear. The resources that fishers require may be distributed more sparsely in our study area, so fishers may need to cover larger areas to sequester enough resources to survive.

Seasonal home ranges of fishers in this study were generally larger during winter than during summer. This result is contrary to that reported by Weir (1995), who observed that home ranges were largest during the summer. This difference may be the result of Weir (1995) using translocated animals, unfamiliar with their surroundings, that were establishing home ranges during summer. All of the fishers in this study were resident adults that were presumably familiar with the habitats in their home range. Thus, they may have been able to locate resources more effectively because of this familiarity. To examine the relationship between season and home range size more closely, we need to collect sufficient locations for more fishers to be able to calculate additional seasonal home ranges.

The preliminary result of differences in home range sizes among females with kits may be the result of habitat quality affecting home range size. Thompson and Colgan (1987) reported that home ranges of

martens that included uncut forest were smaller than those that included logged forest; the difference in home range size was attributed to the differences in resources available between these habitats. The differences that we observed between the sizes of home ranges that included extensive floodplain ecosystems and those without may also be the result of the same relationship. Large, declining black cottonwoods for whelping and structurally complex habitats for foraging are found in the highest densities in extensive floodplain ecosystems. Correspondingly, those home ranges that were comprised primarily of extensive floodplain habitats were smaller than those without them. To be able to examine this trend more closely, we need to tag and monitor additional female fishers whose home ranges do not include extensive floodplain ecosystems.

The home ranges of the fishers in this study appear to follow the intrasexually exclusive spacing pattern that is common among members of the genus *Martes* (see Powell 1994, Weir 1995). We observed very little overlap of annual home ranges among female fishers, but extensive overlap between the home ranges of F01 (male) and F09 (female). The only overlap of female home ranges that we observed occurred on the Manson River, between F04 - F07 and F07 - F02. The respective locations that contributed to this spatial overlap occurred at very different times and may be the result of temporal avoidance (Weir 1995).

We were unable to document many examples of juvenile dispersal because of low survivorship of juveniles and difficulties capturing this age class. We were only able to follow 2 of 7 juvenile fishers for more than a month: F10 during November and December 1997 and F06 from March to October 1998. The distance and area over which F10 travelled while she was transient were large compared to F06 and other transient fishers reported elsewhere in the literature. Weir (1995) reported that 2 translocated fishers in south-central British Columbia ranged over at least 900 km<sup>2</sup> while transient. As noted by Weir (1995), large rivers and elevational changes were not barriers to movement; during F10's transient period, she crossed over both the Mesilinka and Ingenika Rivers and was located at elevations to 1,200 m. The farthest that female fishers in Maine dispersed was 22.6 km from their natal territories (Arthur *et al.*: 1993), which was substantially less than the net dispersal distance exhibited by F10 (77 km). More work should be directed to examining the factors affecting dispersal patterns of juvenile fishers.

## **5.6 Habitat Use**

Because very few habitat descriptions have been collected to date, the majority of the discussion in this section focuses on the progress of sampling habitat use at each spatial scale. Habitat description data is scheduled to be collected during the 1999-2000 fiscal year.

### **5.6.1 Landscape Scale**

Fishers in our study area used the SBSmk2 biogeoclimatic variant more frequently than other variants. This result was not unexpected because we trapped primarily in the SBSmk2. The ranges of 7 of the 20 fishers that we monitored were comprised almost entirely of this variant. Conclusions regarding landscape selection by fishers should only be drawn once use versus availability analyses have been completed.

We have had difficulty meeting the minimum number of locations required to perform these landscape-scale analyses (i.e., home range estimation; 25 locations per fisher throughout the year). Currently, we have enough data to perform landscape level analyses for 6 fishers (1 M, 5 F). For known fishers, we have the opportunity to collect more locations on an additional 2 fishers.

We likely do not need to focus effort at obtaining locations specifically for landscape-scale comparisons because the majority of data used for landscape-scale analyses will be generated while collecting data needed for stand and patch-scale analyses.

### **5.6.2 Stand Scale**

As recorded during aerial telemetry flights, the frequent use of hybrid spruce stands as well as regenerating clearcuts or burns is not unexpected. Both of these stand types comprise substantial proportions of our study area and use of these stand types may not constitute any preference by fishers for these stand types. Conclusions regarding habitat selectivity should only be drawn after the appropriate use versus availability analyses have been performed.

For known animals, we have the potential to assess habitat selectivity at the stand scale for 7 annual home ranges (2 M, 5 F), 6 summer home ranges (2M, 4 F), and 6 winter home ranges (2M, 4 F), assuming that none of the currently tagged fishers die before they can be re-tagged. To date, we have collected sufficient data to examine stand-scale habitat selectivity for 4 annual home ranges but no seasonal home ranges. Thus, we need to focus effort on obtaining 25 stand-scale locations per season for each radio-tagged fisher. Also, in addition to collecting

information on the use of stands, we need to collect information on the availability of stands so that we can complete selectivity analyses.

### 5.6.3 Patch Scale

Although we have collected 114 patch-scale locations to date, we cannot determine how close we are to reaching the data requirements to perform selectivity analyses. Patch-scale habitat analyses are conducted by comparing the patches used by fishers to typical patches found in each stand type. Thus, we need to determine the stand types of all of the patch-scale locations before we can assess whether we have reached the sample sizes necessary to assess selectivity.

We will likely need at least 5 locations in each stand type to establish a reliable index of the patches that fishers use within each stand type. Future effort needs to be directed towards determining the stands in which patch-scale locations occur, evaluate the data requirements for each fisher, and measure both the patches used by fishers and representative patches within each stand type.

### 5.6.4 Element Scale

#### 5.6.4.1 Natal and Maternal Dens

We have identified 8 natal and 4 maternal dens, all of which were located in large diameter ( $x = 108$  cm), declining black cottonwood or balsam poplar trees. Unlike eastern studies, where fishers whelp in smaller diameter trees (Maine:  $x = 45$  cm, Paragi 1990; New England:  $x = 66$  cm, Powell *et al.* 1997; Wisconsin:  $x = 60.9$  cm, Gilbert *et al.* 1997), fishers in our study seemed to use atypically large trees in which to whelp. These types of trees appear to have distinctive characteristics that make them suitable for denning (Weir 1995).

All of the dens consisted of holes through the hard outer sapwood into cavities in the inner heartwood. Black cottonwood trees are prone to decay of the heartwood at an early age (Maini 1968), but appear to form cavities sufficient for rearing by fishers only when the bole at the cavity height is greater than 54 cm diameter. For the cavity to be used by fishers, it also appears that the cavity entrance may need to be greater than 5 m above ground. Thus, for fishers to use black cottonwood trees for natal or maternal dens, it appears that the trees need to have heart rot and a bole diameter greater than 54 cm at 5 m above ground. Elements with all of these traits may be rare across the landscape of the SBS biogeoclimatic zone and may be an important component in the selection of home ranges by female fishers (Weir 1995). Future work

needs to determine the frequency with which these features occur and the effects of the distribution of these elements on female fishers.

The aspects of the den openings were significantly different from random with the mean aspect south, which likely conferred some thermal advantages to the female and her kits. Although Powell *et al.* (1997) did not find that female fishers in central New England selected den openings with any specific aspect, Paragi (1990) found that the mean aspect of natal dens in Maine was to the south. The southern aspect of the entrance, in addition to the height of the cavity, likely maximises the amount of solar radiation that enters the den cavity. This likely confers some thermal advantages to the female and kits (Leonard 1980). Thus, our data supports the hypothesis that fishers select dens that offer a favourable microclimate (i.e., high above ground, facing the sun). However, the aspect of the entrance may be selected to avoid cold northerly winds or may be a function of the availability of the attribute. Possible future effort may be directed towards examining the distribution the aspects of branch-hole entrances, determining if the aspect of maternal dens (i.e., those used after the natal den) favours the south, and examining which environmental factors affect selection of entrance aspect.

#### 5.6.4.2 Resting Sites

One of the goals of examining habitat selection at the element spatial scale was to determine the effects of temperature on rest site selection by fishers. We will probably need at least 3 locations of each of the 4 resting site types for each fisher to assess this relationship. To date, we have identified 15 resting sites for 9 fishers. Thus, additional effort should be directed towards collecting an equal number of samples of each resting site type for each fisher. However, obtaining many samples may be difficult. A sequential sampling approach and power analysis should be used to determine the minimum sample size after at least 10 more resting sites have been identified (25 total).

### 5.7 Reproduction

The patterns of whelping that we observed were broadly compatible with results reported elsewhere. We recorded 6 female fishers using natal dens at the beginning of April. The mean whelping date of the 5 females with kits was 8 April, which was not substantially different from that reported by Weir (1995) in south-central British Columbia (10 April). However, in eastern portions of their range, fishers whelp much earlier (4 March - 24 March, Powell *et al.* 1997). This difference in

whelping dates is likely because of climatic differences and seasonal food availability between the two regions.

Female fishers in this study changed dens as the rearing season progressed. Although we located only 4 maternal (i.e., post-natal) dens, we observed that each of these females abandoned their natal den after 5 to 8 weeks of use. This period of use of the natal den was longer than that reported by Powell *et al.* (1997) in New England and Paragi (1990) in Maine, who each noted that female fishers used 1-5 dens over a 6-8 week period while rearing their kits. Elsewhere in British Columbia, female fishers changed dens after 2-3 weeks of occupancy (R.D. Weir, unpublished data). We were likely unable to locate subsequent dens for 4 of the 6 females because of the decreased time that females spent at later dens. However, females with home ranges that did not include extensive riparian habitats tended not to use maternal dens (F09, F04). The availability of suitable denning opportunities perhaps affects the likelihood of a female moving her kits to maternal dens. To examine this relationship more closely, we should intensively monitor females with kits for the entire rearing season to locate all maternal dens that are used following parturition.

#### 5.7.1 Den Attentiveness Monitoring

The ease of use and reliability of data collected varied widely with the methods that we used to monitor den attentiveness of females. The best method of assessing den fidelity was through the use of data loggers connected to a receiver and antenna. The data logger provided the most accurate and informative data because it did not fail to detect arrivals or departures from the den.

Both remote video and still cameras missed some of the events at the den trees, which made subsequent data unreliable. The main problem with both the remote video camera and still cameras was the use of infra-red sensors. The sensors need to be trained very specifically on the route which will be used by the fisher. If many travel routes exist at a den tree, it is virtually impossible to obtain reliable data unless all possible travel routes can be covered by the sensors. Unfortunately, because of the structural complexity often surrounding the dens, an impractical number of sensors would be needed for the video camera and still camera systems to be totally reliable.

Both the passive and active infra-red sensors used with both the video and still cameras also seemed to be extremely sensitive to solar radiation. It appeared that when sunlight warmed the boles of the den trees, the infra-red sensors were triggered. The active infra-red sensors used with the still cameras were also susceptible to movement of

vegetation and heat sources. Thus, we recorded repeated detections that were caused by factors other than movement by an animal. Despite several configurations of sensitivity, scope, and distance of the infra-red sensors, we were unable to overcome this problem.

Radiotelemetry, both ground and aerial, provided some data on den attentiveness but was more labour intensive and generally not an appropriate use of effort. The point locations that we obtained from telemetry added very little to the data base on den fidelity. Continuous monitoring by personnel provided much more useful data and was the least invasive for the animals. However, having a crew sitting for hours monitoring only one fisher was not an effective use of resources. This technique should be used only when there are not enough data loggers to monitor all den sites.

Future den monitoring work should use telemetry data loggers as the primary source of data gathering. To ensure that the data logger is collecting data properly in the field, batteries should be recharged and data should be downloaded from the data loggers on a weekly basis during April and May. Additionally, remote video cameras can be used at specific dens for which the fisher has few options to ascend or descend the tree. This way, we can be assured of detecting the female whenever she leaves or returns to her den. From data collected using these two methods, we will hopefully be able to assess litter size and determine which factors affect den attentiveness, such as photoperiod, temperature, or solar radiation.

## 6.0 CONCLUSIONS

We have met several of the objectives of the study by following 20 radio-tagged fishers between 1996 and 1999. Unfortunately, high mortality, poor transmission of signals from earlier transmitters, expedited collar rot-away, and low capture success have all contributed to the relatively low number of transmitter-days that we have collected on this project to date.

We have collected sufficient locations of fishers to analyse habitat relationships at all four spatial scales for 6 fishers. However, we need to collect more locations for additional fishers and also describe the habitats that are available at each scale.

We have identified 8 natal and 4 maternal dens of female fishers with kits, all of which have been in large diameter, declining black cottonwood trees. These elements are likely rare across the landscape and the density of these structures may be an important factor in

affecting home range size of female fishers. We monitored den attentiveness by females with kits using several techniques. We have hopefully refined these methods so that we can effectively determine the factors that affect den attentiveness. We have been unable to examine the productivity of female fishers because the remote sensing cameras proved to be ineffective.

We have documented fishers using a variety of resting sites throughout the year, but have not collected enough samples to examine the relationship between temperature and the types of structures used for resting.

## 7.0 LITERATURE CITED

- Arthur, S.M., T. Paragi, and W.B. Krohn. 1993. Dispersal of juvenile fishers in Maine. *Journal of Wildlife Management* 57:868-874.
- Banci, V. 1987. Ecology and behaviour of wolverine in Yukon. M.Sc. Thesis, Simon Fraser University, Burnaby, British Columbia.
- . 1989. A fisher management strategy. British Columbia Ministry of Environment, Wildlife Bulletin Number B-63. Victoria, British Columbia.
- B.C. Ministry of Forests and B.C. Ministry of Environment, Lands, and Parks. 1995. Forest Practices Code of British Columbia: Biodiversity Guidebook. Victoria, British Columbia.
- Demarchi, D.A. 1995. Ecoregions of British Columbia, fourth edition. British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia.
- Geological Survey of Canada. 1988. UTM conversion software. Ottawa, Ontario.
- Gilbert, J.H., J.L. Wright, D.J. Lauten and J.R. Probst. 1997. Den and rest-site characteristics of American marten and fisher in northern Wisconsin. Pages 135-145 *in* G. Proulx, H.N. Bryant, and P.M. Woodward, editors. *Martes: taxonomy, ecology, techniques, and management*. Provincial Museum of Alberta, Edmonton.
- Hovey, F.W. 1998. The Home Ranger. British Columbia Ministry of Forests, Revelstoke.
- Jones, J.L. 1991. Habitat use of fisher in northcentral Idaho. M.Sc. Thesis, University of Idaho, Moscow.
- Kie, J.G., J.A. Baldwin, and C.J. Evans. 1994. CALHOME: Home range analysis program: user's manual.

- Krebs, J. 1993. Wolverine ecology and habitat use in the North Columbia Mountains. Draft Working Plan 1993-1998.
- Leonard, R.D. 1980. The winter activity and movements, winter diet, and breeding biology of the fisher (*Martes pennanti*) in southeastern Manitoba. M.Sc. Thesis, University of Manitoba.
- MacKinnon, A., C. DeLong, and D. Meidinger. 1990. A field guide for identification and interpretation of ecosystems of the northwest portion of the Prince George Forest Region. Land Management Handbook 21. Victoria, British Columbia.
- Maini, J.S. 1968. Silvics and ecology of *Populus* in Canada. Pages 21-69 in J.S. Maini and J.H. Crayford eds., Growth and utilization of poplars in Canada. Department of Forestry and Rural Development, Ottawa, Ontario.
- Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist. 37:223-249.
- Nams, V.O. 1991. Locate II software guide. Pacer Software, Truro, Nova Scotia.
- Paragi, T.F. 1990. Reproductive ecology of female fishers in southcentral Maine. M.Sc. Thesis. University of Maine, Orono.
- Powell, R.A. 1982. The fisher: natural history, ecology, and behavior. University of Minnesota Press, Minneapolis.
- . 1994. Structure and spacing of *Martes* populations. Pages 101-121 in S.W. Buskirk, A.S. Harestad, M.G. Raphael, and R.A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press, Ithaca, New York.
- Powell, S.M., E.C. York, J.J. Scanlon, and T.K. Fuller. 1997. Fisher maternal den sites in central New England. Pages 265-278 in G. Proulx, H.N. Bryant, and P.M. Woodward, editors. Martes: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton.
- Strickland, M.A., C.W. Douglas, M.K. Brown, and G.R. Parsons. 1982. Determining the age of fisher from cementum annuli of the teeth. New York Fish and Game Journal 29:90-94.
- Thompson, I.D., and P.W. Colgan. 1987. Numerical responses of marten to a food shortage in north-central Ontario. Journal of Wildlife Management 51:824-835.
- Weir, R.D. 1995. Diet, spatial organization, and habitat relationships of fishers in south-central British Columbia. M.Sc. Thesis, Simon Fraser University, Burnaby, British Columbia.

- . 1997. Inventory of fishers in the sub-boreal forests of north-central British Columbia. Phase 1: capture and marking. Peace/Williston Fish and Wildlife Compensation Program Report Number 130.
- Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70:164-168.
- Zar, J.H. 1984. Biostatistical analysis. Second edition. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

## 8.0 APPENDIX

Appendix 1. Landscape-scale locations collected for radio-tagged fishers during 1996-99, Williston Fisher Inventory Project. We were unable (or do not have the potential) to collect sufficient data from several fishers before they died or we lost radio contact to calculate home ranges (shaded cells).

| ID              | Name     | Season |        |        | Annual |
|-----------------|----------|--------|--------|--------|--------|
|                 |          | Winter | Summer | Autumn |        |
| F01             | Beau     | 22     | 30     | 9      | 61     |
| F02             | Patches  | 39     | 29     | 12     | 80     |
| F03             | Amelia   | 6      | 33     | 0      | 39     |
| F04             | Cali     | 15     | 18     | 0      | 33     |
| F05             | Solo     | 4      | 28     | 6      | 38     |
| F06             | Fester   | 3      | 12     | 3      | 18     |
| F07             | Inka     | 15     | 26     | 10     | 51     |
| F08             | Haden    | 2      | 0      | 0      | 2      |
| F09             | Olsie    | 23     | 27     | 9      | 59     |
| F10             | Luci     | 3      | 0      | 4      | 7      |
| F11             | Clouds   | 2      | 0      | 2      | 4      |
| F12             | Penelope | 0      | 0      | 3      | 3      |
| F13             | Rose     | 0      | 0      | 4      | 4      |
| F14             | Manson   | 1      | 0      | 3      | 4      |
| F15             | Jewel    | 3      | 0      | 1      | 4      |
| F16             | Frankie  | 0      | 6      | 0      | 6      |
| F17             | Sensai   | 6      | 0      | 2      | 8      |
| F20             | Fin      | 8      | 0      | 0      | 8      |
| F30             | Fraser   | 3      | 0      | 0      | 3      |
| F300            | Linnea   | 6      | 0      | 2      | 8      |
| Total           |          | 161    | 209    | 70     | 440    |
| Effective total |          | 113    | 191    | 32     | 338    |

Appendix 2. Stand-scale locations collected for each radio-tagged fisher during 1996-99, Williston Fisher Inventory Project. We were unable to estimate home ranges for future stand-scale habitat analyses for some fishers (shaded cells).

| ID              | Name     | Sex | Season |        |        | Annual |
|-----------------|----------|-----|--------|--------|--------|--------|
|                 |          |     | Winter | Summer | Autumn |        |
| F01             | Beau     | M   | 9      | 17     | 6      | 32     |
| F02             | Patches  | F   | 23     | 15     | 11     | 49     |
| F03             | Amelia   | F   | 0      | 12     | 0      | 12     |
| F04             | Cali     | F   | 7      | 11     | 0      | 18     |
| F05             | Solo     | F   | 1      | 14     | 6      | 21     |
| F06             | Fester   | M   | 2      | 7      | 1      | 10     |
| F07             | Inka     | F   | 8      | 13     | 7      | 28     |
| F09             | Olsie    | F   | 17     | 14     | 8      | 39     |
| F10             | Luci     | F   | 3      | 0      | 2      | 5      |
| F11             | Clouds   | F   | 1      | 0      | 1      | 2      |
| F12             | Penelope | F   | 0      | 0      | 1      | 1      |
| F13             | Rose     | F   | 0      | 0      | 2      | 2      |
| F14             | Manson   | M   | 0      | 0      | 1      | 1      |
| F15             | Jewel    | F   | 2      | 0      | 0      | 2      |
| F16             | Frankie  | F   | 0      | 1      | 0      | 1      |
| F17             | Sensai   | F   | 3      | 0      | 1      | 4      |
| F20             | Fin      | M   | 3      | 0      | 0      | 3      |
| F300            | Linnea   | F   | 3      | 0      | 1      | 4      |
| Total           |          |     | 82     | 104    | 48     | 234    |
| Effective total |          |     | 62     | 57     | 26     | 173    |

Appendix 3. Patch-scale locations collected for radio-tagged fishers during 1996-99, Williston Fisher Inventory Project.

| ID    | Name    | Sex | Season |        |        | Total |
|-------|---------|-----|--------|--------|--------|-------|
|       |         |     | Winter | Summer | Autumn |       |
| F01   | Beau    | M   | 1      | 8      | 1      | 10    |
| F02   | Patches | F   | 10     | 12     | 5      | 27    |
| F03   | Amelia  | F   | 0      | 7      | 0      | 7     |
| F04   | Cali    | F   | 3      | 7      | 0      | 10    |
| F05   | Solo    | F   | 1      | 12     | 3      | 16    |
| F06   | Fester  | M   | 0      | 1      | 0      | 1     |
| F07   | Inka    | F   | 4      | 11     | 3      | 18    |
| F09   | Olsie   | F   | 2      | 9      | 3      | 14    |
| FH    | Clouds  | F   | 1      | 0      | 0      | 1     |
| F15   | Jewel   | F   | 2      | 0      | 0      | 2     |
| F16   | Frankie | F   | 0      | 1      | 0      | 1     |
| F17   | Sensai  | F   | 2      | 0      | 1      | 3     |
| F20   | Fin     | M   | 3      | 0      | 0      | 3     |
| F300  | Linnea  | F   | 1      | 0      | 1      | 2     |
| Total |         |     | 30     | 68     | 17     | 115   |